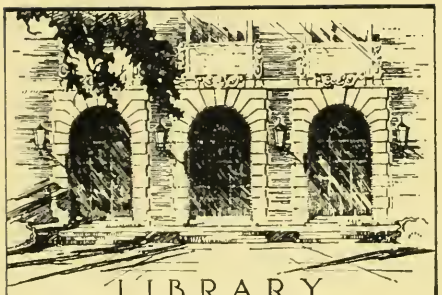

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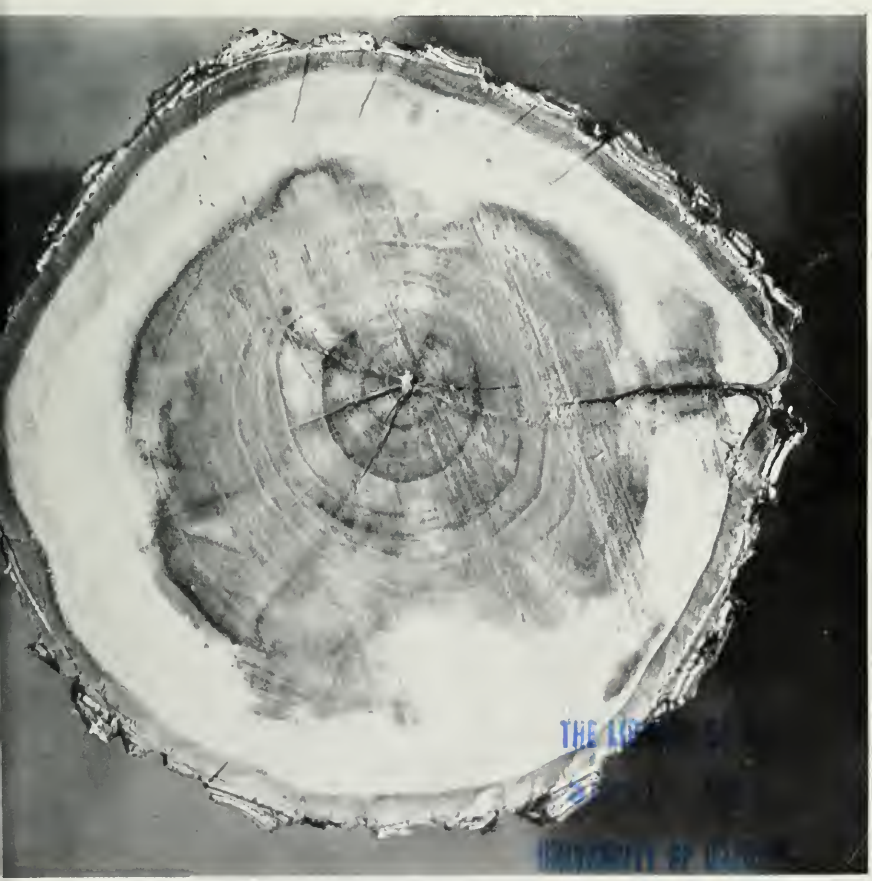
The Wetwood Disease of Elm

J. CEDRIC CARTER



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The Wetwood Disease of Elm

J. CEDRIC CARTER

WETWOOD is a disease, common in elm, that is known to occur also in many other kinds of trees, including apple, birch, fir, hemlock, hickory, linden, maple, mesquite, mulberry, oak, pine, poplar, redbud, sycamore, tulip tree, and willow. In elm, it is caused by the bacterium *Erwinia nimipressuralis* (Fig. 1). Seldom is an elm found that does not show wetwood to some degree. The Siberian elm, *Ulmus pumila* (sometimes incorrectly called Chinese elm), is unusually susceptible to the disease.

As a chronic type of disease, wetwood may contribute to general decline of trees, especially of old trees growing under adverse conditions; it does not cause rapid dying. Elms may show some degree of wetwood annually throughout their life span and still live for 100 or more years.

Wetwood results when bacteria invade and grow in the spring wood of one or more of the annual growth rings in trunks and large branches. The invaded wood becomes dark brown and water-soaked; when the wood is cut, sap oozes out. In trunk cross sections (Fig. 2 and front cover), discoloration appears as dark brown streaks or broken bands in one or several annual rings; or in limited portions of a single annual ring. Discoloration is most extensive in heartwood and older sapwood. However, it may occur in current-season wood.

In wetwood-affected tissues, gas is produced in abundance by the fermenting action of the bacteria on carbohydrates and other materials in the sap. When this gas is confined in the trunk,

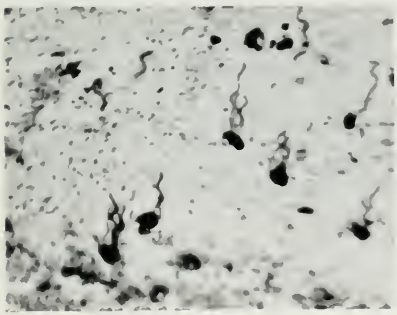

Fig. 1.—*Erwinia nimipressuralis*, the bacterium that causes wetwood in elm, is a small, motile, rod-shaped, single-celled organism having up to six peritrichous flagella attached to its surface.

abnormally high sap pressures develop (Fig. 3). Pressures up to 60 pounds per square inch have been reported. However, pressures of only 5 to 10 pounds per square inch are common in many wetwood-affected trees. The gas contains approximately 46 per cent methane, 34 per cent nitrogen, 14 per cent carbon dioxide, 5 per cent oxygen, and 1 per cent hydrogen. It does not contain carbon monoxide or illuminants.

Sap accumulates under pressure in the diseased wood and produces the water-soaked condition that gives rise to the name *wetwood*. The sap from this wood contains phosphorus and an

Fig. 2.—A section of elm trunk affected with wetwood shows dark brown diseased areas in isolated portions of some annual growth rings (as at arrow *A*) and brown streaking in part of the current-season growth ring (as at arrow *B*).

abundance of potassium. These elements appear to be present in the sap as carbonates. The sap and water extract from the affected wood of a diseased elm are alkaline, while water extract from healthy sapwood and heartwood of normal elms is acid in reaction. The wetwood sap has a pH of 7.11 to 8.55, and the water extract from wetwood-affected wood has a pH of 7.06 to 7.80. The water extract from healthy wood has a pH of 6.11 to 6.60.

External Manifestations

An elm affected by wetwood may show one or more unsightly or detrimental external manifestations of the internal infection. These external manifestations or symptoms include the exuding of fermented sap through wounds, yellowing of foliage (followed by premature defoliation), scorch of foliage, wilting of foliage, dying back of branches with wilted foliage, and general decline of the entire tree.

Flux.—The most conspicuous symptom of wetwood in a tree is the bleeding or exuding of fermented sap through trunk

Fig. 3 (*left*).—Abnormal pressures develop in the diseased wood of elms and other trees affected with wetwood. Many affected trees that do not flux have unusually high pressures, as shown in this picture.

Fig. 4 (*right*).—Bleeding or fluxing through wounds, such as cracks in crotches, is the most common external evidence of wetwood in elm.

wounds. This exuding of sap is commonly called fluxing. The other symptoms (yellowing, scorching, and wilting of leaves, dying of branches, and general decline of the entire tree) may develop when the sap spreads to current-season wood and is transported in the sap stream.

Abnormally high pressures caused by fermentation force the accumulated sap and gas out of the trunk through cracks in crotches (Fig. 4), through wounds made by removal of branches (Fig. 5), through cracks in trunks (Fig. 6), and through other

Fig. 5.—Wounds that result when branches are removed frequently show abundant fluxing. Air-borne bacteria, yeasts, and other fungi may grow in fluxing sap and produce gray-brown, foamlike, ill-smelling, slimy masses called slime flux.

trunk injuries (Fig. 7). The sap or flux is colorless to tan as it oozes out of diseased wood but it turns dark upon exposure to air. When abundant oozing occurs, the flux flows down the trunk, wetting and soaking large areas of bark. As the flux dries, it leaves a light gray to white incrustation on the bark (Fig. 8). Fluxing may occur from April to December. However, it is most conspicuous during July, August, and September, when the wetwood organism is most actively fermenting sap and producing abnormal pressures in the diseased wood. Temperatures are optimum for rapid growth of the wetwood bacterium during these months. Fluxing usually ceases during January, February, and March. During these months, the wounds through which fermented sap has flowed can be detected by the gray to white incrustation of dry flux on the bark.

The exuding wetwood flux is sufficiently toxic to retard or prevent callus formation. It frequently kills the cambium at the

base of a cut (Fig. 9) and around trunk cracks (Fig. 10). Young shoots directly above the fluxing regions may wilt. Tree foliage, young shoots, and grass beneath a fluxing area may be killed if the flux drops on them. Growth of air-borne bacteria, yeasts, and other fungi in the fluxing sap may produce gray to brown, foam-like, ill-smelling, slimy masses around wounds. This slimy material is commonly called *slime flux* (Fig. 11).

Fig. 6.—Fluxing occurs through trunk cracks that penetrate to the wetwood-affected tissues, as in the frost crack shown in this picture.

Fig. 7.—Flux that escapes through holes in the trunk will flow down over the bark. The hole shown above was made by an increment borer.

Fig. 8.—When wetwood flux dries, it leaves a light gray to white incrustation that appears as streaks on the bark of trunks and branches.

Cracks known as frost cracks sometimes develop in the trunks of trees during the winter months when the temperature falls to very low points. Toxic sap in wetwood-affected heartwood, under pressure during the growing season, is forced out

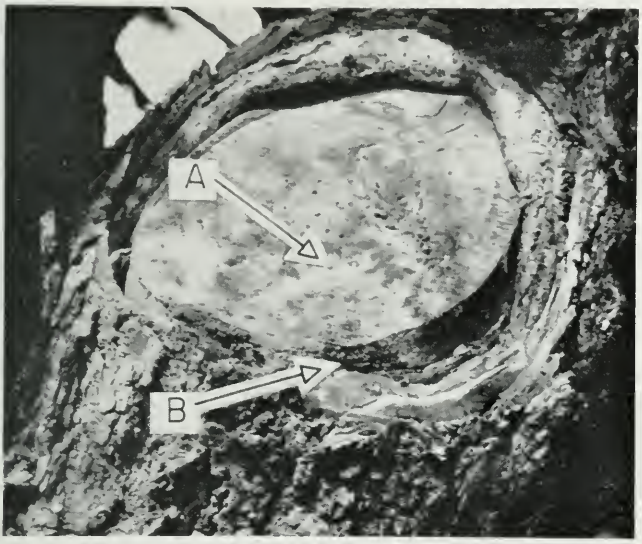

Fig. 9.—Fluxing sap, *A*, of wetwood-affected trees, is sufficiently toxic to retard or prevent formation of callus and to kill bark at the base of a pruning wound, *B*, as shown where the outer bark has been cut away.

through such cracks. It kills the cambium for some distance around the cracks (Fig. 10). Killing of the cambium results in the separation of the bark from the underlying wood. Cracks in the bark with flux oozing through them become apparent in June or July. Many such cracks callus over during the growing season in which they are formed. The callused-over cracks will not flux in succeeding years if the callus tissues produced are strong enough to withstand the pressures that develop in the underlying diseased wood.

Foliage Yellowing.—Leaves on some wetwood-affected trees droop and turn yellow but do not wilt. Many leaves that turn yellow fall prematurely in late July and in August. This yellowing of foliage is not easily differentiated from yellowing that results from adverse climatic conditions. It does not result in any noticeable effect on the growth of trees.

Foliage Scorch.—Foliage scorch resulting from wetwood appears as browning of tissues, usually between the veins but occa-

Fig. 10.—In an elm suffering from wetwood, toxic sap of the diseased wood may ooze through a crack in the trunk, kill the cambium, and cause the bark to separate from the wood. In this picture is shown the trunk of a wetwood-affected tree from which part of the bark has been cut away. The toxic sap has oozed out through the crack (dark line indicated by arrow) and killed the surrounding cambium. The bark has separated from the wood to form an elongate pocket.

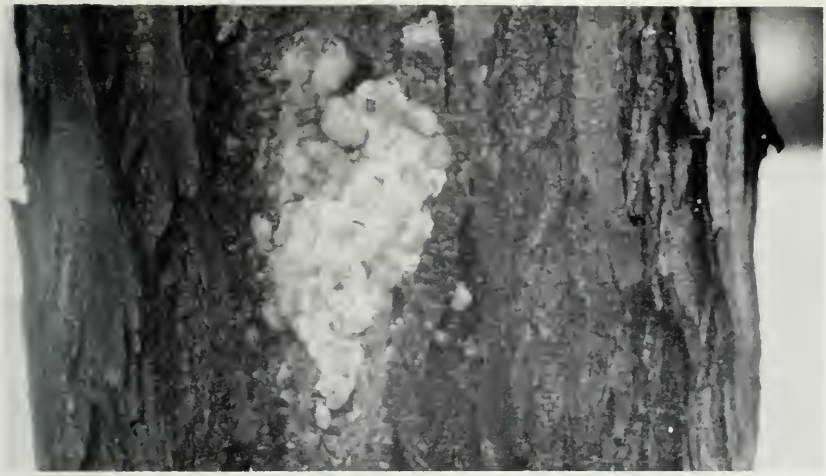

Fig. 11.—Slime flux is an external manifestation of wetwood. It is produced by air-borne bacteria, yeasts, and other fungi that grow in the sap that exudes through wounds.

Fig. 12.—Spread of the wetwood sap into branches may cause browning of tissues between the veins and along the margins of leaves.

sionally along the margins of leaves (Fig. 12). This symptom appears most frequently during late July and August. Many of the scorched leaves drop prematurely. However, scorch does not result in any noticeable effect on the growth of trees.

Foliage Wilt.—Wilt of foliage (Fig. 13) occurs on elms affected with wetwood when a sufficient quantity of toxic sap that

Fig. 13.—Wilt caused by wetwood can be distinguished from other elm wilt diseases only by laboratory analysis.

has accumulated in the trunk wood is carried into the branches. The sap spreads through the current-season spring wood in the branches and produces brown streaks or solid bands of discoloration (Fig. 14). Leaves on affected branches curl upward along their margins; then the petioles become flaccid and the leaves droop. Curl and droop are followed by wilt. Some leaves that wilt rapidly drop from the trees while still green. Other leaves that wilt rapidly take on a dull, greenish-brown or somewhat bronzed

appearance by the time they fall. Leaves that wilt slowly may turn yellow or brown before they fall. Many of the brown leaves become dry and brittle and remain attached to the affected branches for several weeks (Fig. 13).

Foliage wilt resulting from toxic wetwood sap spreading into branches has been observed on elm trees as large as 10 inches dbh (diameter at breast height), but most frequently on trees 3 to 6 inches dbh. Elms more than 10 inches dbh affected with wet-

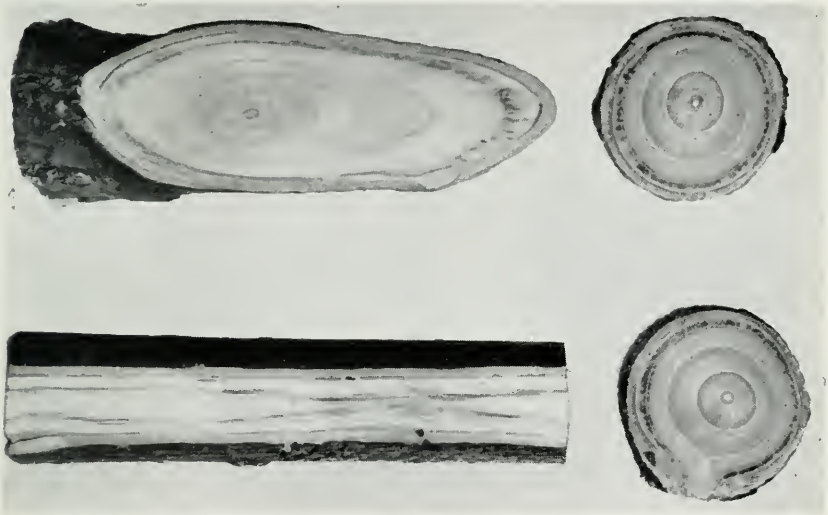

Fig. 14.—Brown streaks produced by wetwood in the young sapwood of branches, especially in the current-season spring wood, is easily confused with similar brown streaks produced by other wilt diseases of elm.

wood usually do not wilt but frequently develop yellowing and browning of foliage, followed by leaf drop and branch dieback. General decline may occur in these larger trees affected with wetwood.

General Decline.—Conspicuous foliage wilt is frequently followed by dying back of affected branches. This dieback may be limited to only tip portions of branches, or it may include entire branches (Fig. 15). In some trees, very few branches die during a single growing season and the trees recover in succeeding years. In other trees, a few scattered branches die annually and the trees show gradual decline over a period of years. In large, old trees, this gradual decline may be attributed to old age, when actually it is one phase of the wetwood disease.

Fig. 15.—Foliage wilt caused by wetwood may be followed by the dying back of affected branches. The dying back may be limited to the tips of branches or it may include entire branches.

Treatment

Because the wetwood organism is usually widespread in the trunk and large branches of an affected tree, removing the branches on which leaves have wilted will not eliminate the disease. Many branches on which the leaves have wilted as a result of wetwood infection do not die but produce a new crop of leaves later in the current growing season or during the following growing season. Removal of branches having wilted leaves should be delayed at least until the spring after wilting is observed, when only the dead wood should be removed. This delay in pruning may prevent premature destruction of the ornamental value of the wetwood-affected tree. Feeding will stimulate growth and may aid the tree in overcoming the adverse effects of the wetwood disease.

Although fluxing is one symptom of wetwood infection, not all trees that flux are affected with wetwood. Before treatment of a fluxing tree is begun, the source of the flux should be determined.

Fluxing and subsequent development of slime flux may arise from bark wounds that penetrate only to the cambial region. Such wounds may be made by insects, ice, wind, lightning, or man-operated tools or machinery. Bacteria may enter through these wounds and ferment the sap in the cambial region. The resulting disease, sometimes referred to as alcoholic flux, is not related to wetwood, and the fluxing that is characteristic of it will not be stopped by boring holes in the affected tree, as recommended below for a wetwood-affected tree. Because the disease is limited to localized wounds, its treatment differs from that for wetwood; the diseased bark should be removed and the underlying wood should be disinfected and coated with a good wound dressing.

A tree that shows wilting of leaves or other symptoms of wetwood should be thoroughly examined for wounds through which toxic sap or flux is exuding. Wounds associated with wetwood extend through the bark and into the heartwood or at least into the old sapwood. Such wounds may be in large branches or in the trunk below wilting branches. A hole bored in the branch or trunk below the wound will allow the flux to escape and will prevent further oozing of flux through the wound. A drain pipe, if properly inserted in the hole, will prevent the flux from coming in contact with the cambium and from flowing over the outer sur-

face of the bark. This treatment prevents toxic sap from being taken into the current-season wood and should prevent additional wilt.

Special care should be taken to assure proper drainage of the toxic sap and gas from the tree affected with wetwood. There is no hard and fast rule for determining where drains should be

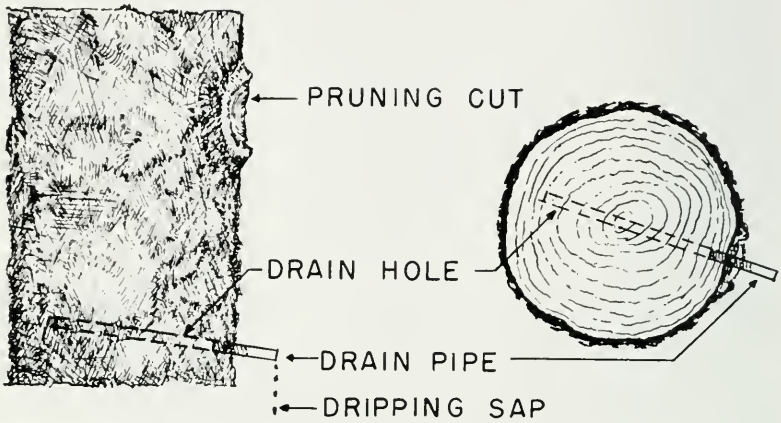

Fig. 16.—Fluxing at pruning wounds may be stopped by a hole bored into the diseased wood where toxic sap and gas have accumulated. The hole should be 6 to 14 inches directly below the wound and slanted so that the toxic sap will flow out through the opening. A short piece of threaded pipe, inserted in the hole only far enough to be firm, will carry the toxic sap away from the tree.

installed. Effective drainage is usually obtained by installing a drain a short distance below the fluxing region. In some cases, a drain installed at the base of the trunk of a large elm has stopped the fluxing of several wounds along the trunk. A fluxing wound, made where a branch has been removed, usually can be drained through a hole three-eighths to one-half inch in diameter bored 6 to 14 inches directly below the fluxing region (Fig. 16).

A fluxing crack in a trunk or in a branch crotch may or may not respond to the same treatment. In some cases, it may be necessary to bore several holes before satisfactory drainage is obtained. A crack in the wood may not be directly beneath the crack in the bark through which the sap is fluxing. A bark crack and a wood crack may be so located that a hole bored directly beneath the bark crack will not be directly beneath the wood crack, and effective drainage will not result. As a rule, it is best to bore the drainage hole to one side and about 6 to 14 inches below the flux-

ing bark crack (Fig. 17 and 18). This hole should be directed toward the probable location of the crack in the wood or toward the center of the heartwood. The drainage hole should have sufficient slant to allow the wetwood sap to flow out, and it should extend through the heartwood to within a few inches of the bark on the opposite side of the trunk (Fig. 19).

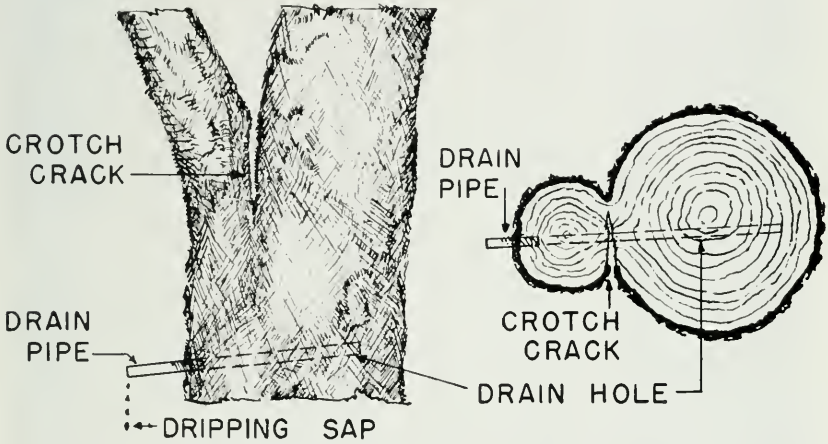

Fig. 17.—Fluxing at cracks in branch crotches usually can be stopped by a hole bored into the diseased wood. The hole should be bored to one side and 6 to 14 inches below the base of the crack so that it will cross the crack in the underlying wood. It should be slanted so that the toxic sap will flow out through the opening. A drain pipe should be inserted in the hole.

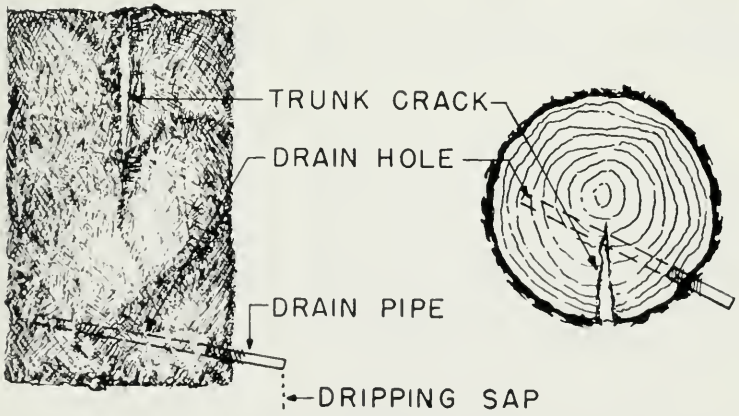

Fig. 18.—Fluxing through a crack in the bark of a trunk should be treated as for a crack in a branch crotch (Fig. 17). The crack in the underlying wood may not be directly beneath the fluxing crack in the bark; the drain hole should be bored so that it will cross the crack in the wood.

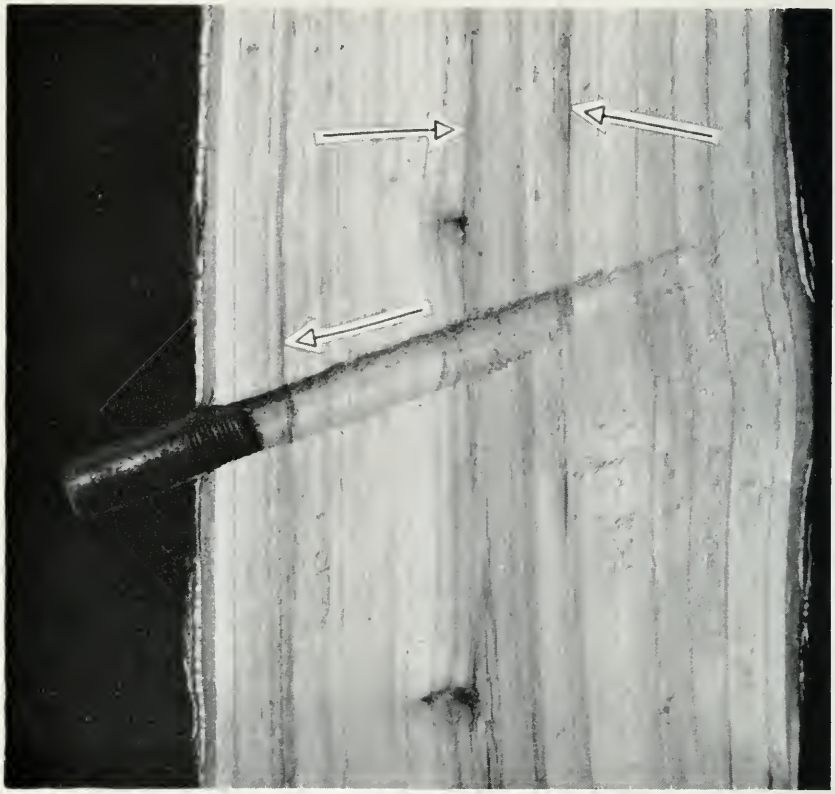

Fig. 19.—This section of a tree shows the drain hole bored at the proper angle and to the proper depth to insure effective drainage and the drain pipe so inserted that it does not penetrate diseased wood (discolored wood indicated by arrows) and interfere with drainage of the sap that accumulates.

Precautions

Precautions should be taken to prevent spreading of wetwood bacteria from diseased to healthy trees. Although wetwood appears to be present in most elms, it occurs only occasionally in most other kinds of trees. Tools used in pruning elms should be treated with a disinfectant to prevent their spreading bacteria to other branches or trees. Denatured alcohol, used as a spray or dip, is a satisfactory disinfectant.

Cures

Even the most effective sap and gas drainage will not cure a tree of wetwood. It will only alleviate the situation by preventing fluxing through wounds.

Efforts have been made to cure wetwood by treating affected trees internally and externally with chemical compounds. None of the treatments reported to date has been successful.

A tree treated with chemical compounds should not be pronounced cured unless the wetwood organism in the tree has been killed. Fluxing is arrested on some wetwood-affected trees by the sealing of wounds with callus growth. Whether or not a tree has been cured can be determined only by laboratory tests on specimens from the discolored heartwood and older sapwood. Suitable samples for laboratory tests can be obtained with an increment borer. If the bacteria are still alive in the discolored wood, although fluxing has ceased, the tree has not been cured; only the fluxing has been arrested.

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